

# **VLASOV ANTENNA DATA FOR ELECTROMAGNETIC CODE VALIDATION**

**Andrew Greenwood and Kyle Hendricks**

**June 2003**

**Final Report**

**APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.**



**AIR FORCE RESEARCH LABORATORY  
Directed Energy Directorate  
3550 Aberdeen Ave SE  
AIR FORCE MATERIEL COMMAND  
KIRTLAND AIR FORCE BASE, NM 87117-5776**

---

Using Government drawings, specifications, or other data included in this document for any purpose other than Government procurement does not in any way obligate the U.S. Government. The fact that the Government formulated or supplied the drawings, specifications, or other data, does not license the holder or any other person or corporation; or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

If you change your address, wish to be removed from this mailing list, or your organization no longer employs the addressee, please notify AFRL/DEHP, 3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776.

Do not return copies of this report unless contractual obligations or notice on a specific document requires its return.

This report has been approved for publication.

//signed//

THOMAS A. SPENCER, DR-III  
Project Manager

//signed//

REBECCA N. SEEGER, Col, USAF  
Chief, High Power Microwave Division

//signed//

L. BRUCE SIMPSON, SES  
Director, Directed Energy Directorate

<b>REPORT DOCUMENTATION PAGE</b>					<i>Form Approved OMB No. 0704-0188</i>	
<small>The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</small> <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>						
<b>1. REPORT DATE (DD-MM-YYYY)</b> 03-06-2003		<b>2. REPORT TYPE</b> Final			<b>3. DATES COVERED (From - To)</b> 01-05-2003 to 03-06-2003	
<b>4. TITLE AND SUBTITLE</b> Vlasov Antenna Data for Electromagnetic Code Validation				<b>5a. CONTRACT NUMBER</b>		
				<b>5b. GRANT NUMBER</b>		
				<b>5c. PROGRAM ELEMENT NUMBER</b> 62605F		
<b>6. AUTHOR(S)</b> Andrew Greenwood and Kyle Hendricks				<b>5d. PROJECT NUMBER</b> 4867		
				<b>5e. TASK NUMBER</b> HJ		
				<b>5f. WORK UNIT NUMBER</b> 02		
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> AFRL/DEHP 3550 Aberdeen Ave SE Kirtland AFB, NM 87117-5776					<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> AFRL-DE-TR-2003-1092	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>					<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>	
					<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited.						
<b>13. SUPPLEMENTARY NOTES</b>						
<b>14. ABSTRACT</b> <p>Measured antenna data is provided for validating computational electromagnetic (CEM) computer programs. The subject antenna is the Vlasov antenna, which is formed by cutting a hollow circular cylindrical waveguide at an oblique angle. Measurements are shown for return loss as a function of frequency, the antenna gain as a function of angular location at three frequencies, and the antenna gain as a function of frequency at several angular locations.</p>						
<b>15. SUBJECT TERMS</b> Computational electromagnetics; validation; benchmarks						
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>  Unlimited	<b>18. NUMBER OF PAGES</b>  18	<b>19a. NAME OF RESPONSIBLE PERSON</b> Thomas Spencer	
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			<b>19b. TELEPHONE NUMBER (Include area code)</b> 505-853-3907	



# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Geometry</b>	<b>1</b>
<b>3</b>	<b>Data</b>	<b>1</b>
<b>4</b>	<b>Conclusion</b>	<b>1</b>

## List of Figures

1	Antenna feed structure. . . . .	2
2	Vlasov antenna geometry. . . . .	3
3	Measured antenna/feed return loss $S_{11}$ . . . . .	4
4	Measured and HFSS computed antenna gain as a function of angle at 1.15 GHz, 1.20 GHz, and 1.30 GHz. . . . .	5
5	Measured antenna gain as a function of frequency at $0^\circ$ , $4^\circ$ , $14^\circ$ , and $24^\circ$ . . . . .	6
6	Measured antenna gain as a function of frequency at $28^\circ$ , $32^\circ$ , $34^\circ$ , and $36^\circ$ . . . . .	7
7	Measured antenna gain as a function of frequency at $40^\circ$ , $44^\circ$ , $54^\circ$ , and $64^\circ$ . . . . .	8
8	Measured antenna gain as a function of frequency at $74^\circ$ and $84^\circ$ . . . . .	9

# 1 Introduction

The purpose of this report is to provide measured antenna data for use in validating computation electromagnetic (CEM) computer programs. The subject antenna is the Vlasov antenna[1]–[3], which is formed by cutting a hollow circular waveguide at an oblique angle. The measurements in this report are from an antenna that is cut at an angle of  $26.1843^\circ$ . The end of the antenna is also removed according to the dimensions shown in Section 2. This report shows measurements of the antenna return loss as a function of frequency and the gain as a function of frequency at several angular locations. The gain as a function of angular location is also shown at three distinct frequencies.

# 2 Geometry

The Vlasov antenna radiates an incident  $TM_{01}$  circular waveguide mode. The feed structure employed to launch at  $TM_{01}$  circular waveguide mode is shown in Fig. 1. As mentioned in Section 1, the Vlasov antenna of this report is formed by cutting a hollow circular waveguide at an angle of  $26.1843^\circ$ , as shown in Fig. 2. Fig. 2 also shows how the end of the angular cut is removed. The angles used in the gain plots of Section 3 are measured in degrees above the antenna axis as shown in Fig. 2. Thus, the coordinate system of Fig. 2, an angle of  $0^\circ$  corresponds to a point in the  $z$ -axis while an angle of  $90^\circ$  corresponds to a point on the  $y$ -axis.

# 3 Data

Fig. 3 shows the measured return loss ( $S_{11}$ ) of the antenna and feed structure as a function of frequency from 1.1 GHz to 1.7 GHz. Fig. 4 shows the measured antenna gain as a function of angle from  $0^\circ$  to  $90^\circ$  at 1.15 GHz, 1.20 GHz, and 1.30 GHz. Fig. 4 also shows the results of antenna gain calculations made with the commercial finite element method (FEM) code HFSS[4]. These calculations serve primarily as a data check on the measurements and are not intended as high fidelity code validation data. Figs. 5–8 show the measured antenna gain as a function of frequency from 1.1 GHz to 1.7 GHz at angles of  $0^\circ$ ,  $4^\circ$ ,  $14^\circ$ ,  $24^\circ$  (Fig. 5);  $28^\circ$ ,  $32^\circ$ ,  $34^\circ$ ,  $36^\circ$  (Fig 6);  $40^\circ$ ,  $44^\circ$ ,  $54^\circ$ ,  $64^\circ$  (Fig 7); and  $74^\circ$ ,  $84^\circ$  (Fig. 8).

# 4 Conclusion

The data in this report is intended to aid in the validation of antenna CEM computer programs. It is hoped that the authors of such programs find the data useful.

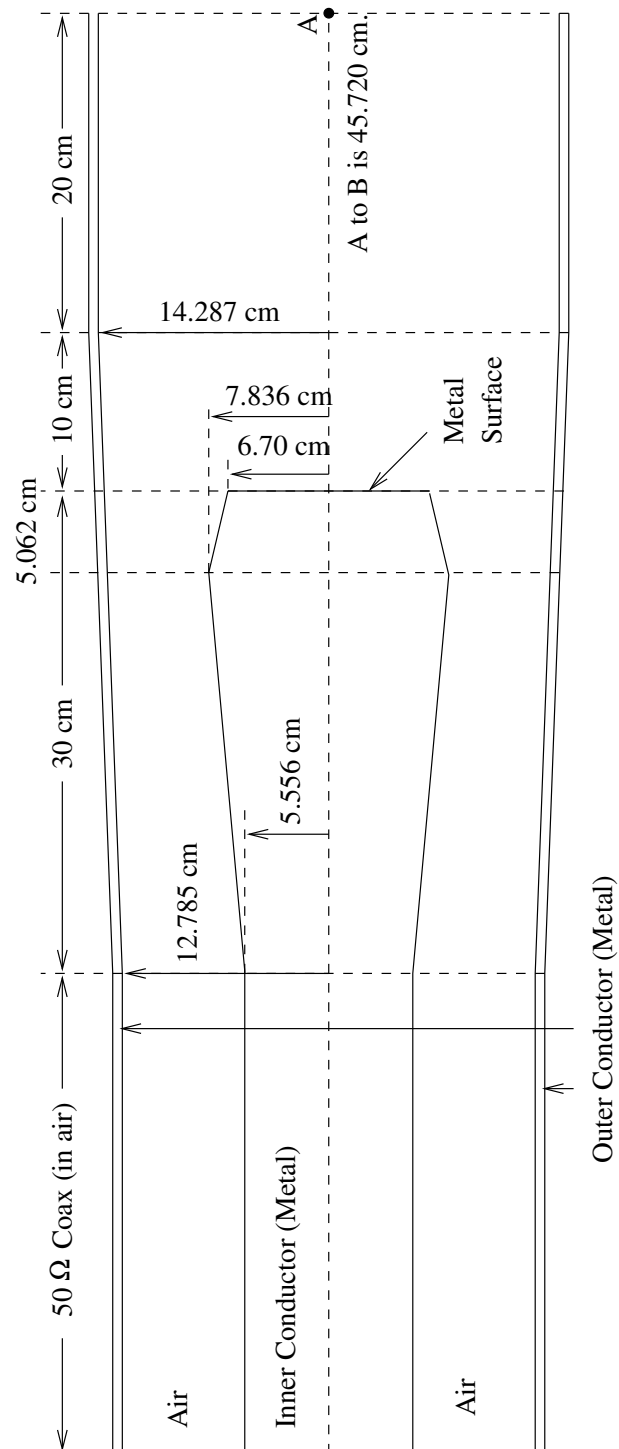


Figure 1: Antenna feed structure.



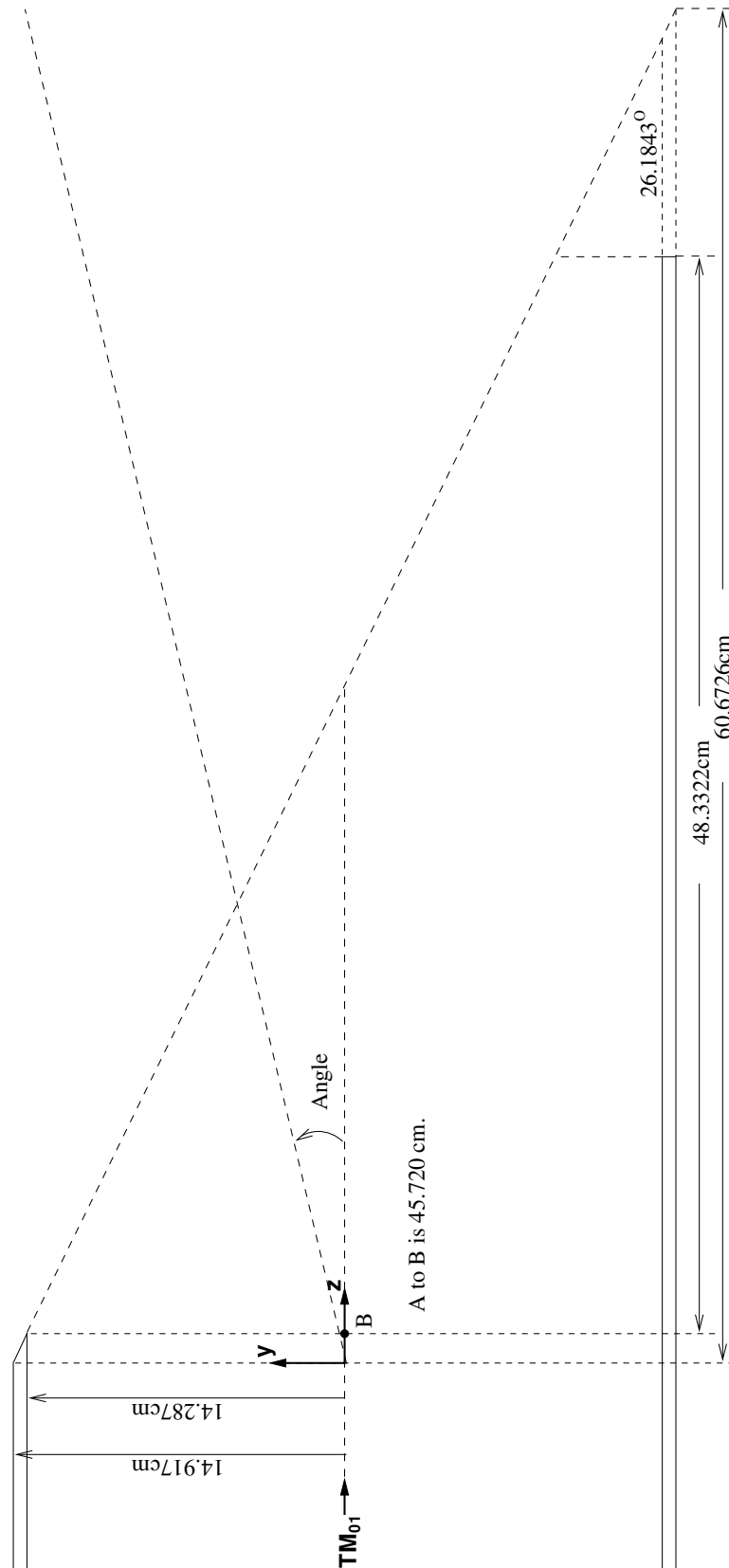


Figure 2: Vlasov antenna geometry.

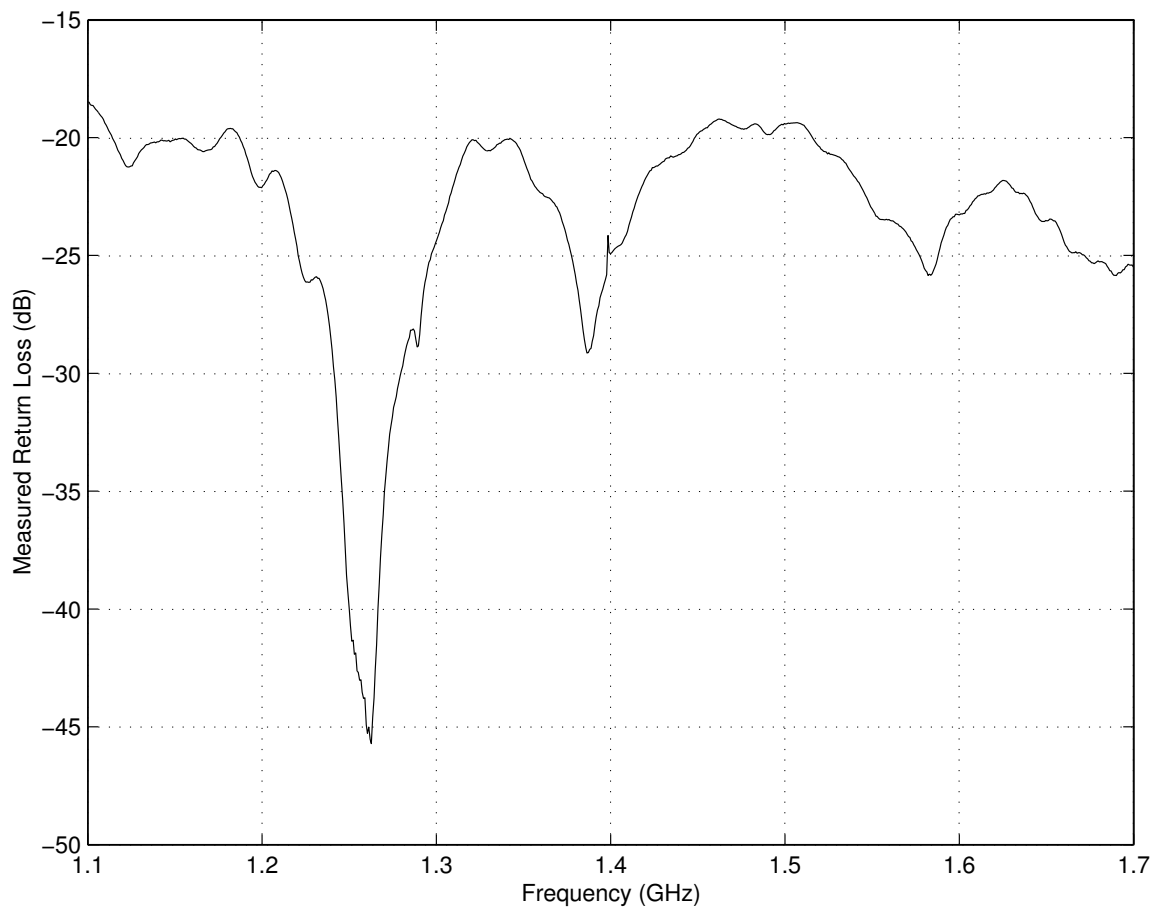


Figure 3: Measured antenna/feed return loss  $S_{11}$ .

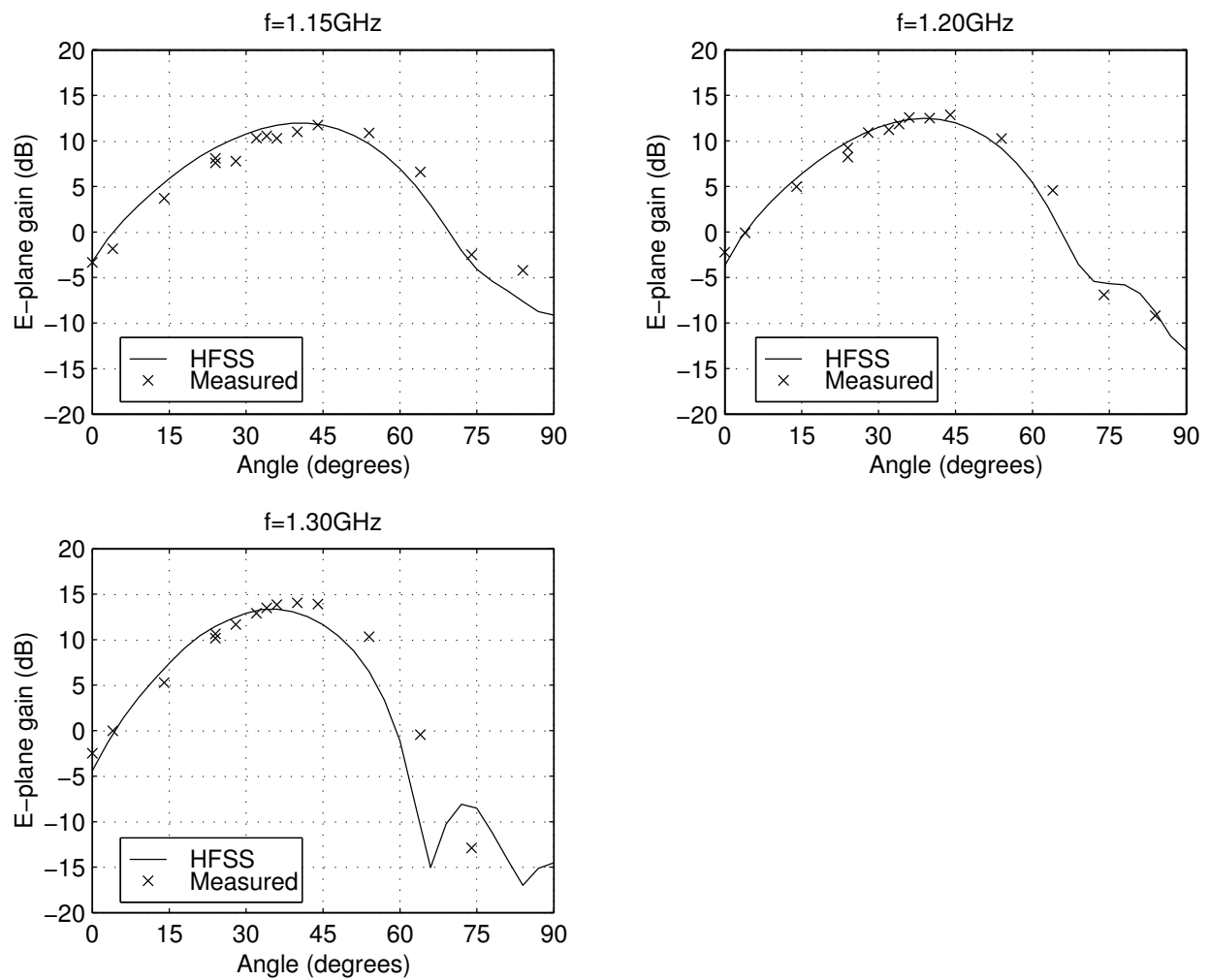


Figure 4: Measured and HFSS computed antenna gain as a function of angle at 1.15 GHz, 1.20 GHz, and 1.30 GHz.

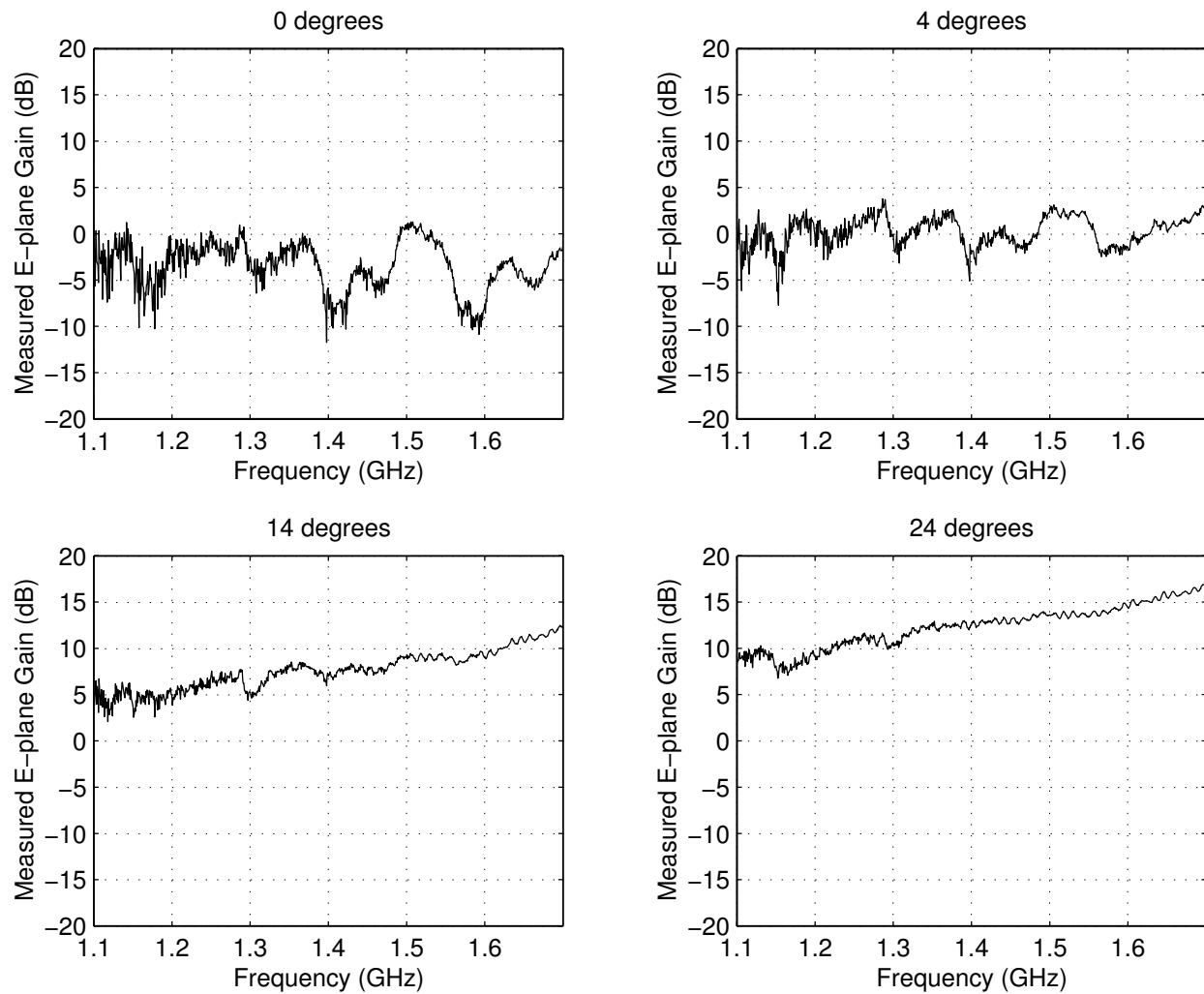


Figure 5: Measured antenna gain as a function of frequency at  $0^\circ$ ,  $4^\circ$ ,  $14^\circ$ , and  $24^\circ$ .

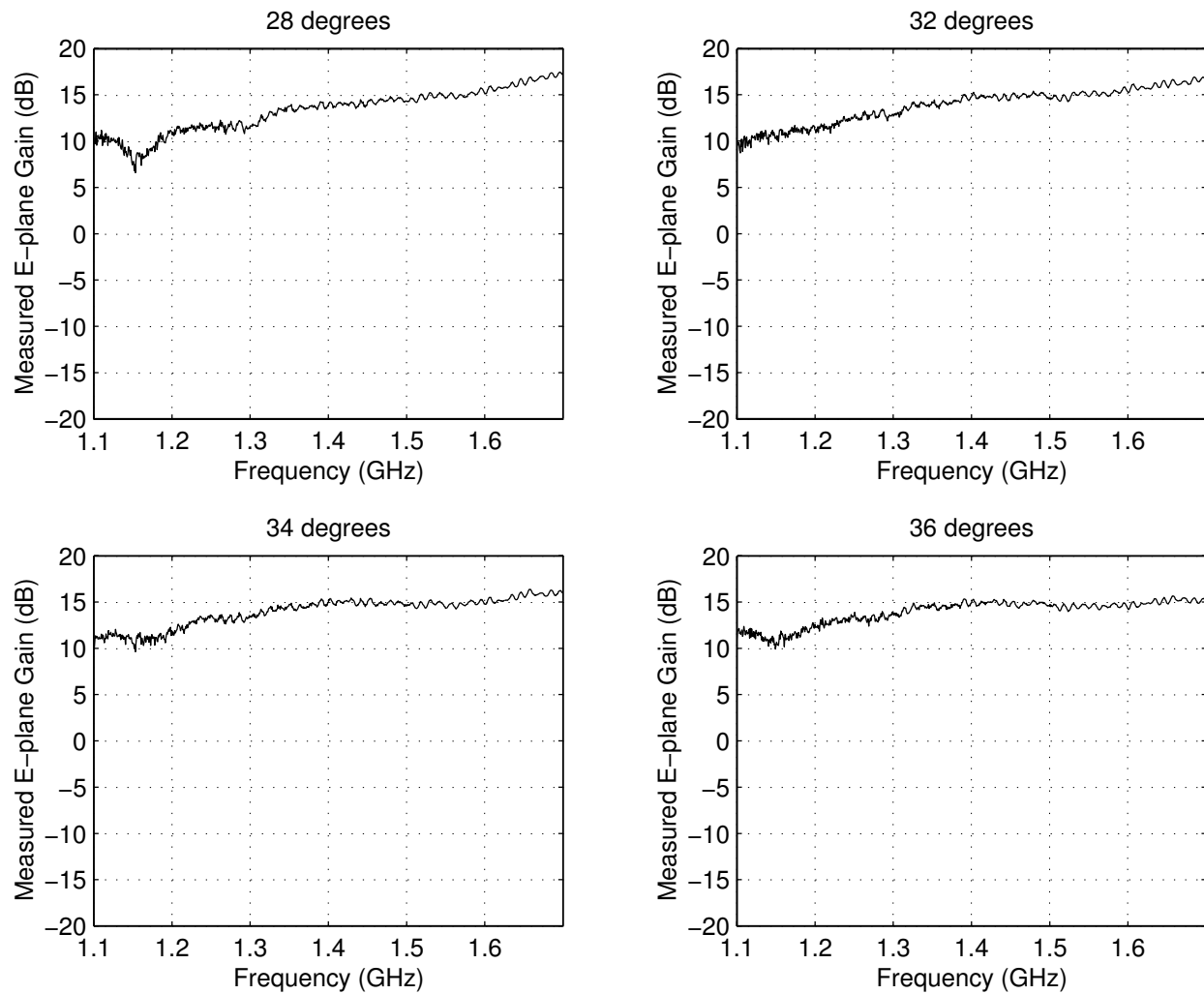


Figure 6: Measured antenna gain as a function of frequency at 28°, 32°, 34°, and 36°.

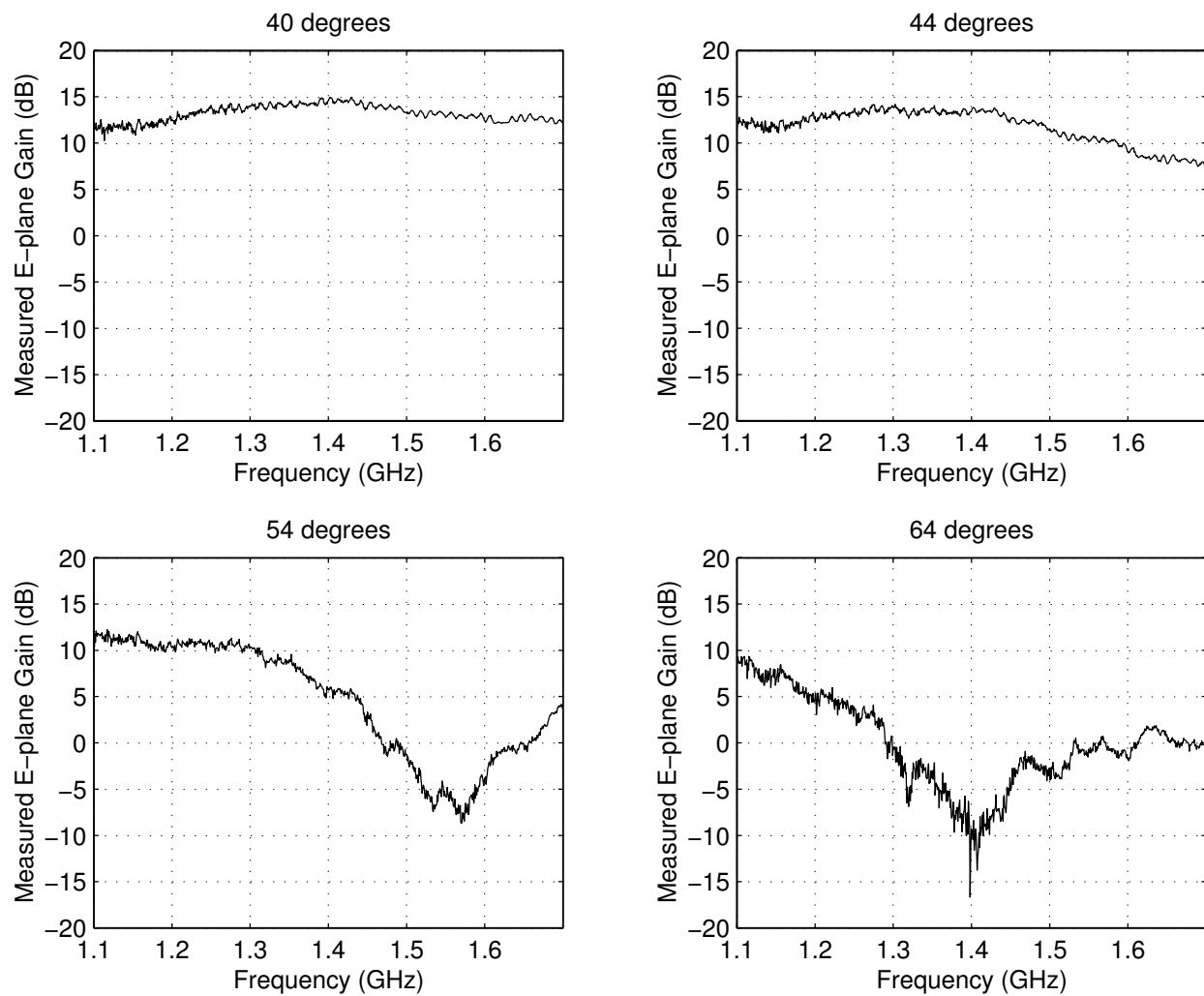


Figure 7: Measured antenna gain as a function of frequency at 40°, 44°, 54°, and 64°.

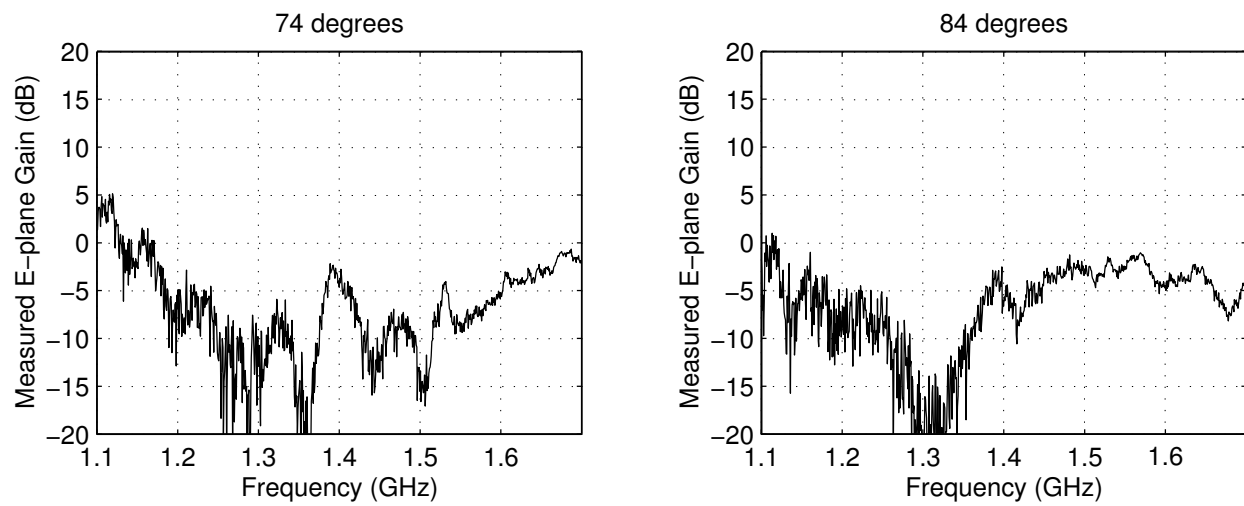


Figure 8: Measured antenna gain as a function of frequency at 74° and 84°.

## References

- [1] S. N. Vlasov and I. M. Orlova, “Quasioptical transformer which transforms waveguide having a circular cross section into a highly directional wave beam,” *Radiofizika*, vol. 17, pp. 148–154, January 1974.
- [2] B. G. Ruth, R. K. Dalstrom, C. D. Schlesiger, and L. F. Libelo, “Design and low-power testing of a microwave vlasov mode converter,” in *IEEE MTT-S International Microwave Symposium*, vol. 3, pp. 1277–1280, 1989.
- [3] J. H. Beggs, *Finite-difference time-domain implementation of surface impedance boundary Conditions in one, two, and three dimensions*. PhD thesis, The Pennsylvania State University, 1993.
- [4] <http://www.ansoft.com>.



## DISTRIBUTION LIST

DTIC/OCF	
8725 John J. Kingman Rd, Suite 0944	
Ft Belvoir, VA 22060-6218	1 cy
AFRL/VSIL	
Kirtland AFB, NM 87117-5776	2 cys
AFRL/VSIH	
Kirtland AFB, NM 87117-5776	1 cy
AFRL/DEHE/Dr. Andrew Greenwood	
Kirtland AFB, NM 87117-5776	1 cy
AFRL/DEHP/Dr. Kyle Hendricks	
Kirtland AFB, NM 87117-5776	1 cy
Official Record Copy	
AFRL/DEHP/Dr. Thomas Spencer	8 cys

